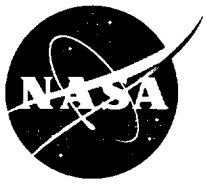
NASA/TM—1998–208529



A Case Study for Probabilistic Methods Validation
(MSFC Center Director's Discretionary Fund Final Report, Project No. 94–26)

J.M. Price and R. Ortega
Marshall Space Flight Center, Marshall Space Flight Center, Alabama

National Aeronautics and
Space Administration

Marshall Space Flight Center

July 1998

Available from:

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090–2934
(301) 621–0390

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487–4650

TABLE OF CONTENTS

LIST OF FIGURES

TECHNICAL MEMORANDUM

A CASE STUDY FOR PROBABILISTIC METHODS VALIDATION (MSFC Center Director's Discretionary Fund Final Report, Project No. 94–26)

1. INTRODUCTION

Probabilistic method is not a universally accepted approach for the design and analysis of aerospace structures. The validity of this approach must be demonstrated to encourage its acceptance as a viable design and analysis tool to estimate structural reliability. The real world uncertainties (such as, defining loads, environment, material properties, geometric variables, manufacturing process, engineering models, and human errors) which make probabilistic methods attractive, also make it difficult to validate. A fundamental step in any probabilistic methodology is the identification and characterization of the drivers which are the inputs to the deterministic engineering failure model. A better understanding of the effect of driver assumptions on the probabilistic analysis is needed to encourage the use of probabilistic methods for the design and analysis of aerospace structures.

2. OBJECTIVE

The objective of this study is to develop a well characterized finite population of similar aerospace structures that can be used to (1) validate probabilistic codes, (2) demonstrate the basic principles behind probabilistic methods, (3) formulate general guidelines for characterization of material drivers (such as elastic modulus) when limited data is available, and (4) investigate how the drivers affect the results of sensitivity analysis at the component/failure mode level.

3. APPROACH

The general approach is to create a well-characterized finite population of similar aerospace structures, load these structures in some prescribed manner, measure their response, and compare the measured response to the predicted response from a probabilistic analysis code.

The structural system selected is a simply supported beam of rectangular cross section that has a single point load applied at midspan. The midspan bottom fiber strain is the measured response. For this structural system, the principle drivers (input parameters) are the point load (P) applied at midspan ($L/2$), the unsupported length (L), the material modulus of elasticity (E), the height of the cross-section (H), and the width of the cross section (B). The moment of inertia (I_z) is a calculated quantity. The strain gauge alignment is assumed to be a secondary driver. The structural system is shown in figure 1.

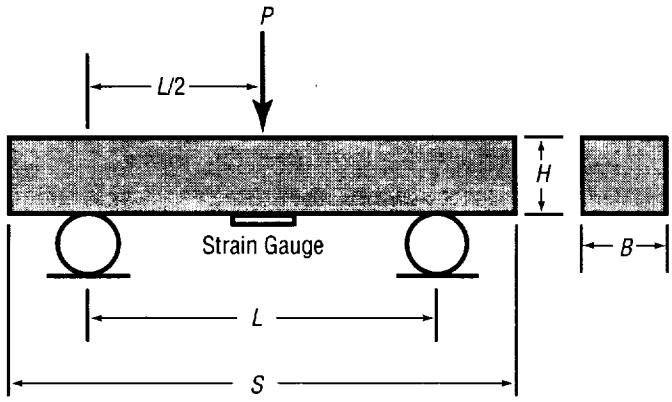


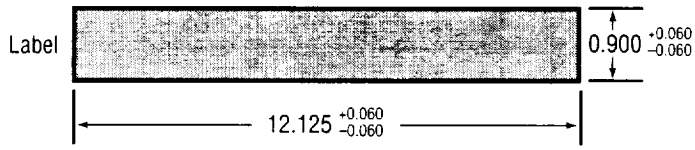
Figure 1. Structural system.

The principle drivers are placed in either a controlled or an uncontrolled distribution category. The distributions used for the point load (P), the unsupported length (L), the cross-section height (H), and the cross-section width (B) are controlled. The elastic modulus and other material properties are placed in the uncontrolled distribution category. Also, the point of load application (midspan) will have some distribution which is not controlled. Uniform distributions for the cross-section height (H) and width (B) were generated. Any type of distribution can be generated for the midspan point load (P) and the unsupported length (L). The overall length of each specimen is the same (12 in.). The specimens were sized such that the beam top (or bottom) fiber stress does not exceed the allowable yield stress from Mil-Handbook 5. The maximum point load that can be applied is 2,750 lb. The maximum unsupported length is 11 in. The elastic modulus distribution will be obtained experimentally. The distribution for the midspan dimension ($L/2$) will not be obtained. It is assumed that it will always be half the unsupported length (L). Every effort will be made to ensure that this assumption remains valid during testing. Also, it is assumed that the actual variation of midspan dimension ($L/2$) is a secondary driver.

4. CREATION OF THE FINITE POPULATION OF SIMPLY SUPPORTED BEAMS

Practical considerations, such as available raw stock, manpower, and time, limited the total population to 500 beams. The total population is divided into 10 bins, each containing 50 beams. The beams are fabricated from a single plate of 2219–T87 aluminum (part number QQ–A–250/30, stock number 9535–00–975–2584) obtained from the Materials and Processes Laboratory at Marshall Space Flight Center. All fabrication work was done by the Materials and Processes Laboratory. The nominal dimensions of the plate are 48 in. × 144 in. × 0.5 in.

The beam fabrication process begins with cutting blanks from the 2219–T87 plate. A total of 550 blanks are fabricated from the aluminum plate, including 50 spares. All specimens are cut with the blank length oriented with the rolling direction of the plate stock. Each blank was cut to the dimensions shown in figure 2 and labeled as shown in figure 3. This completes step 1 of the fabrication process.



All dimensions are in inches. Label each blank on left or right face using a permanent marker.

Figure 2. Specimen blank dimensions.

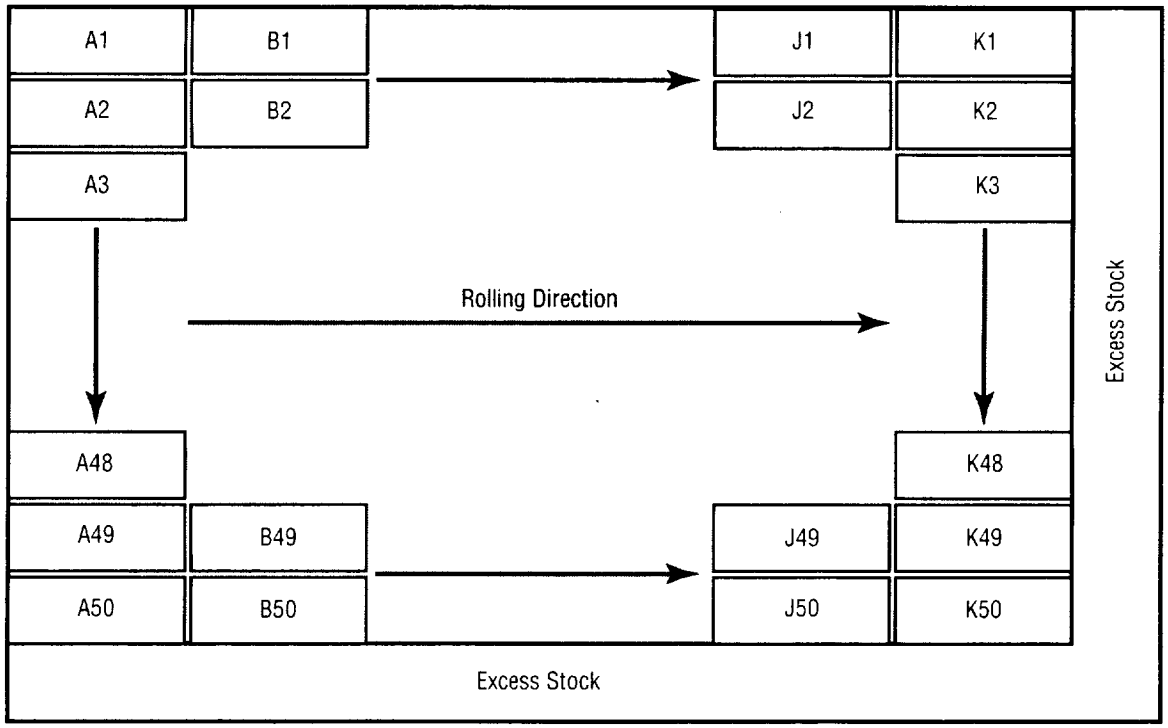
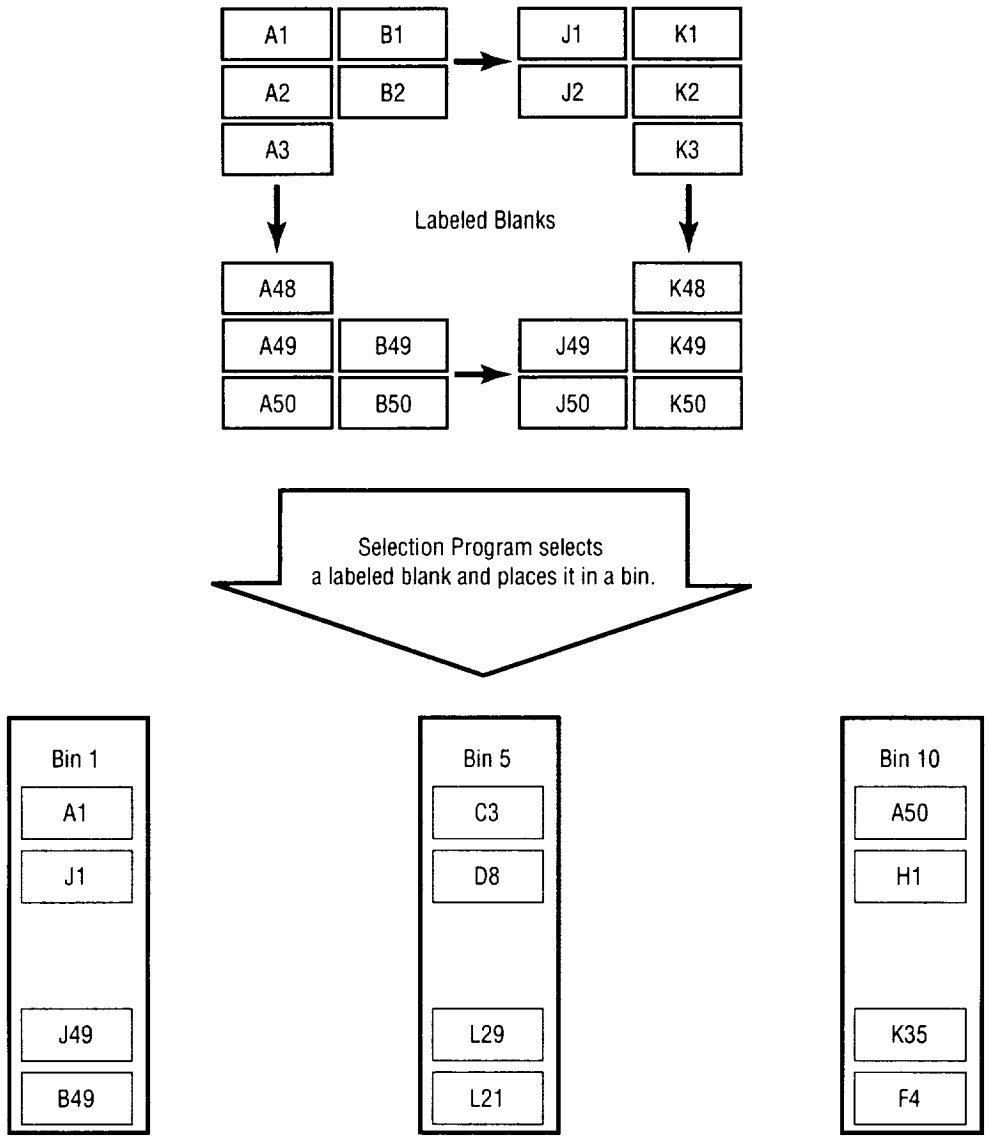


Figure 3. Specimen blank labeling.

Step 2 is analogous to shuffling a deck of cards (the 550 blanks) and then dealing the cards out to each player (a bin). In this case, each player (or bin) gets 50 cards (or blanks) from the deck (or population of 550 blanks). The purpose of step 2 of the fabrication process is to select blanks in such a manner as to minimize the variation of material properties from bin to bin. A computer program was written to randomly select blanks for each bin. This process is illustrated in figure 4. A listing of this program is provided in appendix A and the selection list in appendix B.



Note: There are 50 specimens per bin.

Figure 4. Blank selection process.

Step 3 involves machining the blanks to the dimensions specified in table 1 and figure 1. This step required the most time and effort. To reduce the machining time and the possibility of machining errors, each bin was sent to the Materials and Processes Laboratory as a separate work order. The actual cross-section dimensions (B and H) of each beam were taken at three locations (left end, right end, and midspan) by the Materials and Processes Laboratory. There were a few beams that were "out-of-spec." These "out-of-spec" beams were left in their respective bins. The dimensional bounds of each bin were large enough to allow for any slightly "out-of-spec" beams.

Table 1. Specimen dimensions for each bin.

Bin	Number of Specimens	Length (L), in. (Tolerance ± 0.1 in.)	Height (H), in. (Tolerance ± 0.0125 in.)	Width (B), in. (Tolerance ± 0.006 in.)
1	50	12	0.6375	0.3187
2	50	12	0.6625	0.3312
3	50	12	0.6875	0.3437
4	50	12	0.7125	0.3562
5	50	12	0.7375	0.3687
6	50	12	0.7625	0.3812
7	50	12	0.7875	0.3937
8	50	12	0.8125	0.4063
9	50	12	0.8375	0.4187
10	50	12	0.8625	0.4312

5. CONCLUSION

A well-characterized finite population of constant cross-section beams has been created. This population can be used to set up a probabilistic test problem that can be used to compare various probabilistic structural analysis codes.

APPENDIX A—Listing of the Specimen Selection Program

```
c ... this program generates a list of randomly selected specimens
c ... for the Probabilistic CDDF
c ...
      common/sysio/nu1,nu2,nu3,nu4,nu5,nu6
      common/randcm/iout
      character*1 alist(1000)
      integer list(1000,2),histo(1000)
      integer count,spcnum,sum
      real frac
      double precision rand1,rand2
c ...
      iout = 1
      nu1 = 1
      nu2 = 2
      nu3 = 3
      nu4 = 4
      nu5 = 9
      nu6 = 9
c ...
      rand1 = 1234567.0
      rowfact = 48.001
      colfact = 11.001
      spmx = 529.0
      mxspc = 528
      mnrow=1
      mxrow=48
      mncol=1
      mxcol=11
      nbin = 50
      count = 0
      sum = 0
c ... zero out the histo array
      do 50 i=1,1000
   50 histo(i) = 0.0
c ... open file for output
      open(nu1,file="specmen.lst",status="new")
c ... select specimens
      count = 0
  100 continue
```

```
c ... generate a random row
      call random(frac,rand1)
      rk = frac * spmx
      k = int(rk)
      if (k.eq.0)goto 100
      irow = ( (k-1) / mxcol ) + 1
      icol = k - (( (k-1) / mxcol ) * mxcol)
      write(nu6,9300)k,count,irow,icol
 9300 format(/,1x,'k,count,irow,icol',4i10)
c ... histogram
      spcnum = (irow - 1) * mxcol + icol
      histo(spcnum) = histo(spcnum) + 1
      sum = sum + 1
c ...
      if(count.eq.0)then
c ... if first specimen
      count = count + 1
      list(count,1) = irow
      list(count,2) = icol
      else
c ... check if specimen has been selected
      iflg = 0
      do 500 i=1,count
      if((list(i,1).eq.irow).and.(list(i,2).eq.icol))iflg=1
  500 continue
      if(iflg.eq.1)goto 100
c ... add specimen to list
      count = count + 1
      list(count,1) = irow
      list(count,2) = icol
      end if
c ... check if all specimens have been selected
      if(count.eq.mxspc)goto 1000
      goto 100
 1000 continue
c ... convert column number to a letter
      do 1500 i=1,count
      if(list(i,2).eq.1)alist(i)='a'
      if(list(i,2).eq.2)alist(i)='b'
      if(list(i,2).eq.3)alist(i)='c'
      if(list(i,2).eq.4)alist(i)='d'
      if(list(i,2).eq.5)alist(i)='e'
      if(list(i,2).eq.6)alist(i)='f'
      if(list(i,2).eq.7)alist(i)='g'
      if(list(i,2).eq.8)alist(i)='h'
```

```
      if(list(i,2).eq.9)alist(i)='i'
      if(list(i,2).eq.10)alist(i)='j'
      if(list(i,2).eq.11)alist(i)='k'
 1500 continue
c ... output list
      ibin = 0
      jbin = 0
      write(nu6,9000)
 9000 format(/,1x,'Specimen Selection List')
      write(nu1,9000)
      do 2000 i=1,count
      if(ibin.le.nbin)ibin = ibin + 1
      if(ibin.gt.nbin)ibin=1
      if(ibin.eq.1)then
      jbin = jbin + 1
      write(nu6,9005)jbin
 9005 format(/,1x,'Bin ',i5,/,
     21x,'Selection',1x,'Specimen Number',5x,'Specimen Row/Column')
      write(nu1,9005)jbin
      end if
      spcnum = (list(i,1) - 1) * mxcol + list(i,2)
      write(nu6,9100)ibin,spcnum,list(i,1),alist(i)
 9100 format(1x,i5,10x,i5,15x,i5,' / ',a1)
      write(nu1,9100)ibin,spcnum,list(i,1),alist(i)
 2000 continue
c ... histogram data
      write(nu1,9200)
 9200 format(/,1x,'Histogram Data',/,1x,'Specimen',2x,'Frequency',/)
      do 2500 i=1,count
      write(nu1,9210)i,histo(i)
 9210 format(1x,i5,5x,i5)
 2500 continue
      write(nu1,9220)sum
 9220 format(/,1x,'Sum of All Occurances = ',i10)
c ...
      close(nu1)
c ...
      open(nu2,file="column.lst",status="new")
c ... sort by column (i.e. a thru k)
      do 4000 j=1,11
      do 3500 i=1,count
      if(list(i,2).eq.j)then
      kbin = 1 + ((i-1)/nbin)
      write(nu6,9500)alist(i),list(i,1),kbin
      write(nu2,9500)alist(i),list(i,1),kbin
```

```
 9500 format(1x,a1,' / ',i5,' bin ',i2)
      endif
 3500 continue
 4000 continue
      close(nu2)
      stop
      end
c ... random number generator from Rene 042795
      subroutine random(frac,rand)
c ...
c ... Subroutine random uses an lcg random number generator to generate
c ... uniformly distributed random numbers — r.f. miles, jpl
c ... programer: l. grondalski, l. newlin
c ... date: 1dec87
c ... version: matchr v4,v5,v5.1,v5.2,v5.3,v6,v6.1,v6.2,
c ...          v7,v7.1,v8,v8.1
c ...          matgrm v2,v3,v3.1,v3.2,v3.3,v4,v4.1
c ...
      common/sysio/nu1,nu2,nu3,nu4,nu5,nu6
      common/randcm/iout
      implicit none
      integer iout
      real frac
      double precision rana,ranc,rand,randiv,ranm,ransub,
     &                 rant,ranx
c ...
c ... list of variables
c ...
c ...    frac — uniform (0,1) random variate
c ...    iout — output dump controller
c ...    rana — constant for lcg
c ...    ranc — constant for lcg
c ...    rand — random number seed
c ...  randiv — internal caculation
c ...    ranm — constant for lcg
c ... randsub — internal calculation
c ...    rant — internal calculation
c ...    ranx — internal calculation
c ...
c ... using lcg random # generator
      rana = 671093.0
      ranc = 7090885.0
      ranm = 33554432.0
```

```
c ...
  10 ranx = rana*rand + ranc
     randiv = ranx / ranm
     rant = dint(randiv)
     ransub = rant*ranm
     rand = ranx - ransub
     frac = sngl(rand/ranm)
c ...
     if((frac.eq.0.0).or.(frac.eq.1.0))goto 10
     if(iout.eq.2)write(nu6,*)'ranx=',ranx,'randiv=',randiv,
    &                 'rant=',rant,'ransub=',ransub,
    &                 'rand=',rand,'frac=',frac
c ...
     return
     end
```

APPENDIX B—Specimen Selection List

a / 16 bin 1
a / 35 bin 1
a / 34 bin 1
a / 19 bin 1
a / 40 bin 2
a / 39 bin 2
a / 36 bin 2
a / 8 bin 2
a / 44 bin 2
a / 46 bin 2
a / 24 bin 2
a / 2 bin 3
a / 28 bin 3
a / 11 bin 3
a / 12 bin 3
a / 20 bin 4
a / 13 bin 4
a / 23 bin 4
a / 6 bin 4
a / 7 bin 4
a / 32 bin 4
a / 27 bin 5
a / 26 bin 5
a / 33 bin 5
a / 17 bin 6
a / 47 bin 6
a / 37 bin 6
a / 43 bin 6
a / 22 bin 7
a / 41 bin 7
a / 4 bin 8
a / 38 bin 8
a / 10 bin 8
a / 18 bin 8
a / 25 bin 8
a / 14 bin 8
a / 31 bin 9
a / 45 bin 9
a / 21 bin 9
a / 1 bin 9
a / 5 bin 9
a / 30 bin 9
a / 15 bin 9
a / 3 bin 10
a / 48 bin 10
a / 9 bin 11
a / 42 bin 11
a / 29 bin 11
b / 35 bin 1
b / 29 bin 1
b / 40 bin 1
b / 7 bin 1
b / 11 bin 1
b / 15 bin 1
b / 12 bin 1
b / 21 bin 2
b / 5 bin 2
b / 2 bin 3
b / 9 bin 3
b / 34 bin 3
b / 30 bin 3
b / 3 bin 4
b / 37 bin 4
b / 23 bin 4
b / 8 bin 4
b / 14 bin 4
b / 25 bin 4
b / 6 bin 5
b / 18 bin 5
b / 19 bin 5
b / 41 bin 5
b / 1 bin 6
b / 39 bin 6
b / 13 bin 6
b / 22 bin 6
b / 42 bin 7
b / 17 bin 7
b / 44 bin 8
b / 16 bin 8
b / 43 bin 8

b / 32 bin 9
b / 24 bin 9
b / 36 bin 9
b / 4 bin 9
b / 38 bin 9
b / 10 bin 9
b / 20 bin 10
b / 31 bin 10
b / 48 bin 10
b / 45 bin 10
b / 28 bin 10
b / 46 bin 10
b / 26 bin 10
b / 33 bin 11
b / 27 bin 11
b / 47 bin 11
c / 1 bin 1
c / 46 bin 1
c / 2 bin 1
c / 27 bin 1
c / 22 bin 1
c / 5 bin 1
c / 45 bin 1
c / 28 bin 1
c / 19 bin 1
c / 6 bin 2
c / 47 bin 2
c / 26 bin 2
c / 31 bin 2
c / 32 bin 3
c / 15 bin 3
c / 14 bin 3
c / 21 bin 3
c / 4 bin 3
c / 36 bin 3
c / 3 bin 4
c / 25 bin 4
c / 13 bin 4
c / 33 bin 4
c / 35 bin 5
c / 40 bin 5
c / 8 bin 5
c / 7 bin 5
c / 38 bin 5
c / 37 bin 5
c / 39 bin 6
c / 43 bin 6
c / 29 bin 6
c / 23 bin 7
c / 16 bin 7
c / 48 bin 7
c / 24 bin 8
c / 42 bin 8
c / 44 bin 8
c / 12 bin 8
c / 30 bin 9
c / 11 bin 9
c / 41 bin 10
c / 17 bin 10
c / 18 bin 10
c / 34 bin 11
c / 10 bin 11
c / 20 bin 11
c / 9 bin 11
d / 14 bin 1
d / 23 bin 1
d / 20 bin 1
d / 45 bin 1
d / 4 bin 2
d / 26 bin 2
d / 33 bin 2
d / 44 bin 2
d / 10 bin 3
d / 9 bin 3
d / 29 bin 3
d / 13 bin 3
d / 24 bin 4
d / 18 bin 4
d / 1 bin 4
d / 27 bin 4
d / 6 bin 4
d / 42 bin 5
d / 15 bin 5
d / 16 bin 5
d / 38 bin 5
d / 5 bin 6
d / 22 bin 6
d / 43 bin 6
d / 7 bin 6
d / 31 bin 6

d / 34 bin 6
d / 21 bin 6
d / 48 bin 6
d / 17 bin 7
d / 2 bin 7
d / 12 bin 7
d / 32 bin 7
d / 46 bin 7
d / 8 bin 7
d / 19 bin 7
d / 41 bin 8
d / 40 bin 8
d / 30 bin 8
d / 3 bin 9
d / 28 bin 9
d / 37 bin 9
d / 36 bin 10
d / 35 bin 10
d / 25 bin 10
d / 11 bin 10
d / 39 bin 11
d / 47 bin 11
e / 27 bin 1
e / 22 bin 1
e / 30 bin 1
e / 44 bin 2
e / 21 bin 2
e / 17 bin 2
e / 18 bin 2
e / 39 bin 2
e / 6 bin 3
e / 43 bin 3
e / 29 bin 3
e / 48 bin 3
e / 9 bin 4
e / 37 bin 4
e / 12 bin 4
e / 31 bin 4
e / 2 bin 5
e / 4 bin 5
e / 10 bin 5
e / 36 bin 5
e / 46 bin 5
e / 15 bin 5
e / 35 bin 5
e / 19 bin 6
e / 20 bin 6
e / 25 bin 7
e / 42 bin 7
e / 40 bin 7
e / 28 bin 8
e / 32 bin 8
e / 7 bin 8
e / 38 bin 8
e / 5 bin 8
e / 3 bin 8
e / 1 bin 8
e / 14 bin 9
e / 11 bin 9
e / 24 bin 9
e / 16 bin 9
e / 26 bin 9
e / 45 bin 10
e / 23 bin 10
e / 47 bin 10
e / 33 bin 10
e / 41 bin 10
e / 13 bin 10
e / 8 bin 10
e / 34 bin 11
f / 6 bin 1
f / 21 bin 1
f / 22 bin 2
f / 42 bin 2
f / 8 bin 2
f / 10 bin 2
f / 16 bin 2
f / 5 bin 3
f / 24 bin 3
f / 43 bin 3
f / 48 bin 3
f / 20 bin 4
f / 25 bin 4
f / 34 bin 4
f / 27 bin 4
f / 29 bin 4
f / 37 bin 4
f / 9 bin 5
f / 14 bin 5
f / 3 bin 6

f / 28 bin 6
f / 32 bin 6
f / 13 bin 6
f / 47 bin 6
f / 40 bin 7
f / 23 bin 7
f / 35 bin 7
f / 41 bin 7
f / 2 bin 7
f / 39 bin 7
f / 36 bin 7
f / 38 bin 8
f / 26 bin 8
f / 7 bin 8
f / 11 bin 8
f / 30 bin 9
f / 4 bin 9
f / 1 bin 9
f / 12 bin 9
f / 45 bin 9
f / 33 bin 10
f / 19 bin 10
f / 17 bin 10
f / 44 bin 10
f / 15 bin 10
f / 18 bin 11
f / 31 bin 11
f / 46 bin 11
g / 48 bin 1
g / 12 bin 1
g / 18 bin 2
g / 1 bin 2
g / 47 bin 2
g / 19 bin 2
g / 21 bin 2
g / 42 bin 2
g / 28 bin 2
g / 45 bin 2
g / 34 bin 2
g / 9 bin 3
g / 25 bin 3
g / 36 bin 3
g / 8 bin 3
g / 23 bin 3
g / 29 bin 3
g / 44 bin 3
g / 26 bin 3
g / 10 bin 3
g / 17 bin 4
g / 5 bin 4
g / 32 bin 5
g / 20 bin 5
g / 33 bin 5
g / 41 bin 5
g / 11 bin 5
g / 24 bin 5
g / 43 bin 5
g / 3 bin 6
g / 37 bin 6
g / 40 bin 7
g / 15 bin 7
g / 4 bin 7
g / 31 bin 8
g / 46 bin 8
g / 13 bin 8
g / 39 bin 8
g / 16 bin 8
g / 35 bin 8
g / 30 bin 9
g / 14 bin 9
g / 27 bin 9
g / 6 bin 10
g / 7 bin 10
g / 2 bin 10
g / 22 bin 11
g / 38 bin 11
h / 35 bin 1
h / 24 bin 1
h / 22 bin 1
h / 4 bin 1
h / 23 bin 2
h / 39 bin 2
h / 11 bin 3
h / 45 bin 3
h / 31 bin 3
h / 14 bin 3
h / 42 bin 4
h / 28 bin 4
h / 13 bin 4
h / 16 bin 4

h / 30 bin 5
h / 44 bin 5
h / 43 bin 5
h / 2 bin 5
h / 37 bin 5
h / 34 bin 5
h / 9 bin 5
h / 41 bin 6
h / 1 bin 6
h / 21 bin 6
h / 17 bin 6
h / 10 bin 7
h / 3 bin 7
h / 27 bin 7
h / 25 bin 7
h / 20 bin 7
h / 47 bin 7
h / 33 bin 8
h / 26 bin 8
h / 6 bin 8
h / 5 bin 9
h / 15 bin 9
h / 19 bin 9
h / 29 bin 9
h / 7 bin 9
h / 40 bin 9
h / 32 bin 10
h / 46 bin 10
h / 8 bin 10
h / 48 bin 11
h / 12 bin 11
h / 38 bin 11
h / 18 bin 11
h / 36 bin 11
i / 12 bin 1
i / 3 bin 1
i / 6 bin 1
i / 28 bin 2
i / 21 bin 2
i / 8 bin 2
i / 39 bin 3
i / 9 bin 3
i / 11 bin 3
i / 7 bin 3
i / 45 bin 4
i / 16 bin 4
i / 40 bin 4
i / 25 bin 4
i / 23 bin 4
i / 2 bin 4
i / 10 bin 5
i / 41 bin 5
i / 44 bin 5
i / 5 bin 5
i / 22 bin 6
i / 35 bin 6
i / 34 bin 6
i / 30 bin 6
i / 26 bin 7
i / 43 bin 7
i / 32 bin 7
i / 33 bin 7
i / 37 bin 7
i / 48 bin 7
i / 19 bin 7
i / 42 bin 8
i / 29 bin 8
i / 15 bin 8
i / 36 bin 9
i / 17 bin 9
i / 31 bin 9
i / 24 bin 9
i / 47 bin 9
i / 4 bin 10
i / 14 bin 10
i / 20 bin 10
i / 46 bin 10
i / 13 bin 10
i / 27 bin 10
i / 38 bin 10
i / 1 bin 10
i / 18 bin 11
j / 19 bin 1
j / 40 bin 1
j / 46 bin 1
j / 45 bin 1
j / 13 bin 1
j / 36 bin 1
j / 28 bin 2
j / 2 bin 2

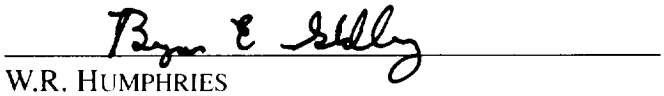
j / 31 bin 2
j / 11 bin 2
j / 16 bin 3
j / 17 bin 3
j / 20 bin 4
j / 9 bin 4
j / 22 bin 4
j / 25 bin 5
j / 23 bin 5
j / 14 bin 5
j / 42 bin 6
j / 33 bin 6
j / 44 bin 6
j / 29 bin 6
j / 18 bin 6
j / 48 bin 6
j / 30 bin 6
j / 8 bin 7
j / 3 bin 7
j / 10 bin 7
j / 32 bin 7
j / 5 bin 8
j / 24 bin 8
j / 7 bin 8
j / 6 bin 8
j / 39 bin 8
j / 26 bin 8
j / 43 bin 9
j / 21 bin 9
j / 4 bin 9
j / 27 bin 9
j / 41 bin 9
j / 37 bin 9
j / 47 bin 10
j / 35 bin 10
j / 34 bin 10
j / 12 bin 10
j / 15 bin 10
j / 1 bin 11
j / 38 bin 11
k / 13 bin 1
k / 1 bin 1
k / 44 bin 1
k / 45 bin 1
k / 46 bin 1
k / 6 bin 1
k / 27 bin 2
k / 15 bin 2
k / 19 bin 2
k / 32 bin 2
k / 33 bin 2
k / 5 bin 3
k / 10 bin 3
k / 40 bin 3
k / 30 bin 3
k / 17 bin 3
k / 7 bin 4
k / 48 bin 4
k / 37 bin 4
k / 29 bin 4
k / 21 bin 5
k / 23 bin 5
k / 8 bin 5
k / 43 bin 6
k / 4 bin 6
k / 47 bin 6
k / 22 bin 6
k / 38 bin 6
k / 25 bin 6
k / 24 bin 6
k / 3 bin 7
k / 14 bin 7
k / 41 bin 7
k / 12 bin 7
k / 28 bin 7
k / 11 bin 7
k / 26 bin 8
k / 36 bin 8
k / 39 bin 8
k / 34 bin 8
k / 9 bin 8
k / 18 bin 9
k / 31 bin 9
k / 35 bin 10
k / 20 bin 10
k / 16 bin 10
k / 42 bin 11
k / 2 bin 11

APPROVAL

A CASE STUDY FOR PROBABILISTIC METHODS VALIDATION
(MSFC Center Director's Discretionary Fund Final Report, Project No. 94–26)

J.M. Price and R. Ortega

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.



W.R. HUMPHRIES
DIRECTOR, STRUCTURES AND DYNAMICS LABORATORY

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1998	Technical Memorandum

4. TITLE AND SUBTITLE

A Case Study for Probabilistic Methods Validation
(MSFC Center Director's Discretionary Fund Final Report, Project 94–26)

5. FUNDING NUMBERS

6. AUTHORS

J.M. Price and R. Ortega

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

8. PERFORMING ORGANIZATION REPORT NUMBER

M–878

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Washington, DC 20546–0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NASA/TM—1998–208529

11. SUPPLEMENTARY NOTES

Prepared by Structures and Dynamics Laboratory, Science and Engineering Directorate

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Unclassified–Unlimited
Subject Category 37
Nonstandard Distribution

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Probabilistic method is not a universally accepted approach for the design and analysis of aerospace structures. The validity of this approach must be demonstrated to encourage its acceptance as a viable design and analysis tool to estimate structural reliability. The objective of this study is to develop a well characterized finite population of similar aerospace structures that can be used to (1) validate probabilistic codes, (2) demonstrate the basic principles behind probabilistic methods, (3) formulate general guidelines for characterization of material drivers (such as elastic modulus) when limited data is available, and (4) investigate how the drivers affect the results of sensitivity analysis at the component/failure mode level.

14. SUBJECT TERMS	15. NUMBER OF PAGES
probabilistic methods, finite population, validate	24
	16. PRICE CODE A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102